

High quality monitoring of water systems using in situ automatic measurement stations that incorporate real-time data quality analysis tools

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Presented by..... **John B. Copp, Ph.D.**

Overview

- Brief Introduction to Primodal/ULaval
- RSM30 Monitoring Stations/Networks
- Real-Time Data Quality Evaluation
- Discussion for the Future

Introducing Primodal / U Laval

➤ Expertise

- Process Engineering, Design, Control, Modelling, Monitoring and Data Analysis
 - COMMON THEME → Data Evaluation
 - the need for accurate and representative data

Introducing Primodal / U Laval

➤ Primodal Inc. / Primodal Systems Inc.

- Offices in Hamilton, ON.; Quebec, QC; Kalamazoo, MI
- PI: Water/Wastewater Consulting Firm
- PSI: Monitoring Equipment

➤ modelEAU / Université Laval

- Based in Quebec, QC.
- Water and Modeling-based Research Group

Primodal / U Laval Cooperation

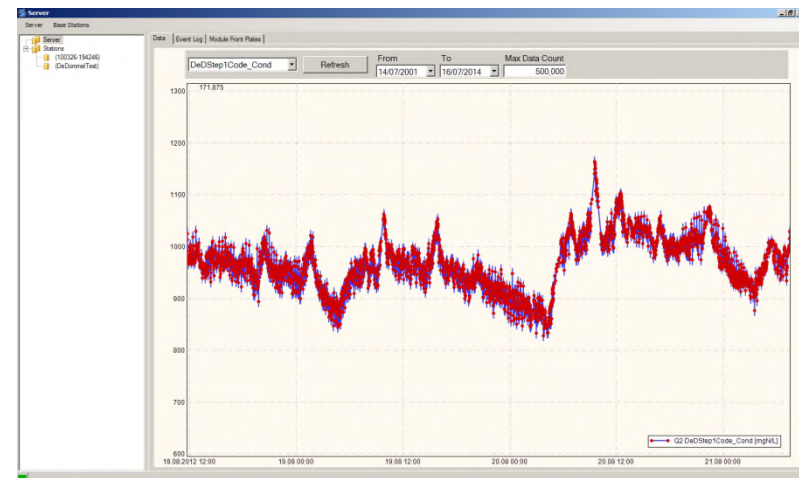
➤ Platform

- RSM30™ monitoring station
- Portable and sensor independent



➤ Advanced Data Evaluation Tools

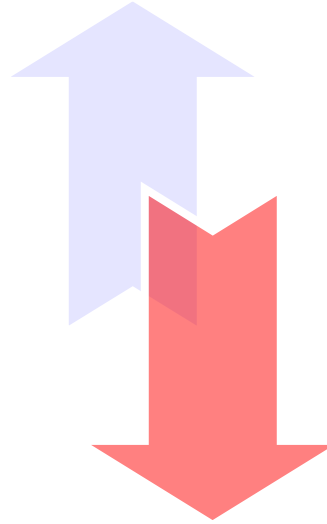
- *PrecisionNow*©
- Real-time data evaluation methods and data validation algorithms



Monitoring for Process Understanding

➤ The Potential

- Tracking Impacts
- Limitless applications for study
- Whole-system modelling
- Decision-making



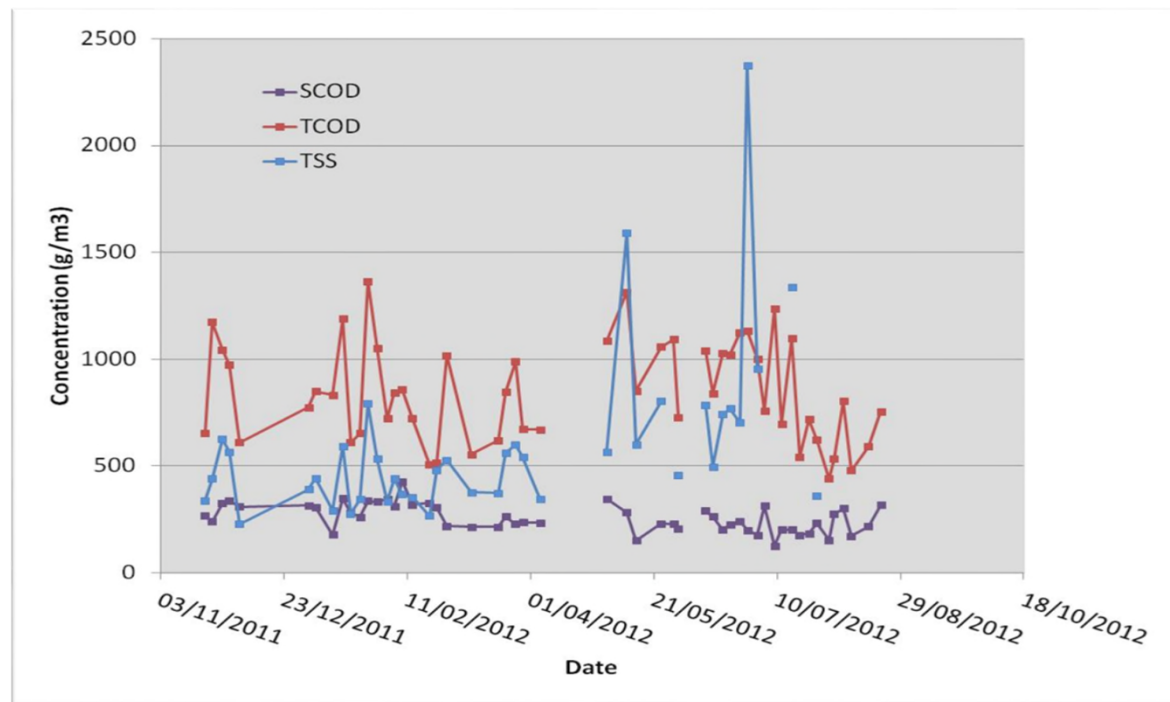
➤ The Pitfalls

- Data Accuracy
 - system behavior
- Data Graveyards
- Communication
- Data Expertise
- Data Maintenance
- Data Quality

Issues

➤ Typical Data

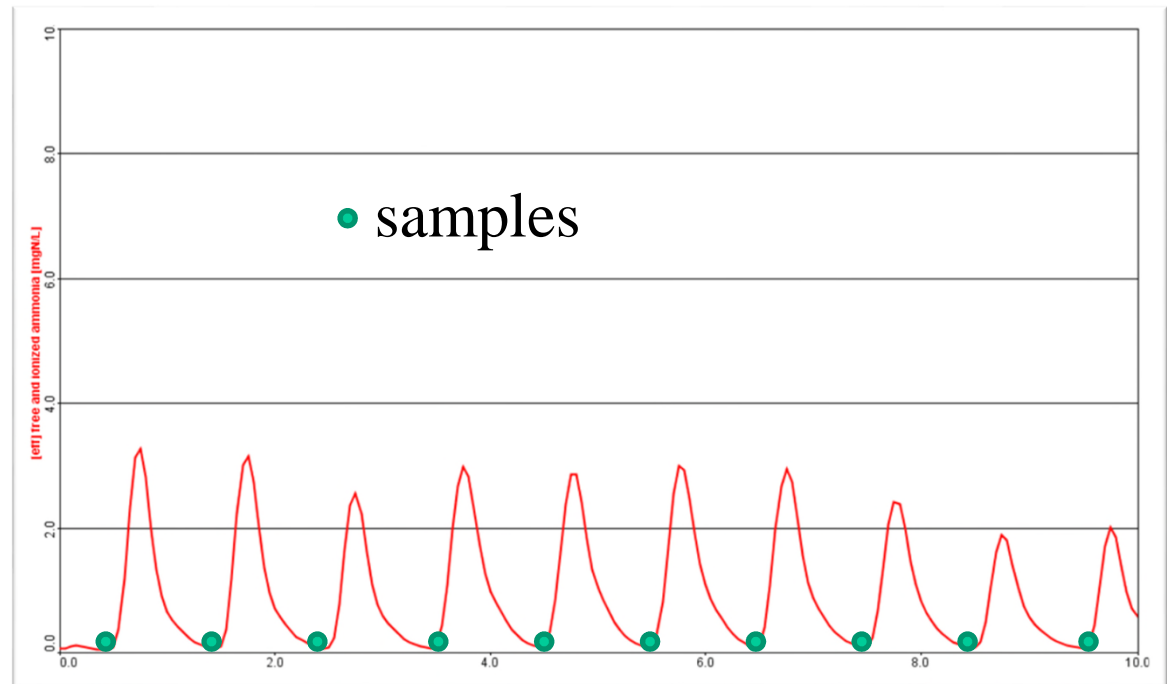
- Grab samples
- 1-yr time period
- Variations
 - Time of Day
 - Season
 - Weather
 - Location
 - ...



Issues

➤ Grab Sample Issues

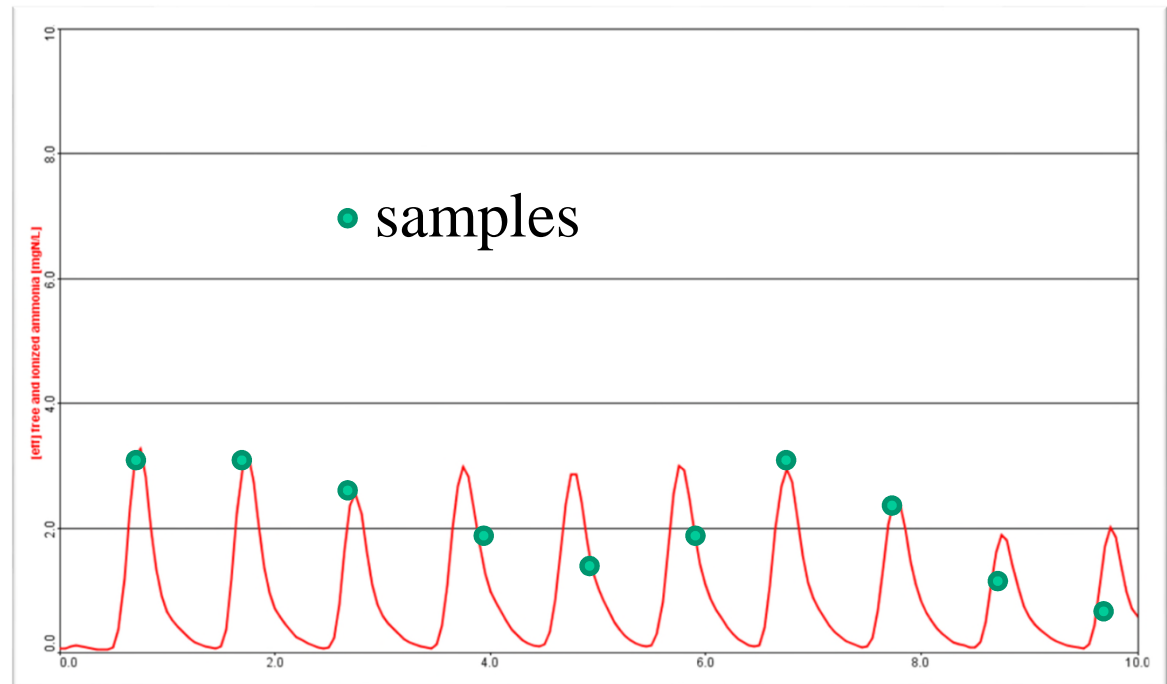
- Behavior missed
- Trends missed
- Events missed
- Average case missed



Issues

➤ Grab Sample Issues

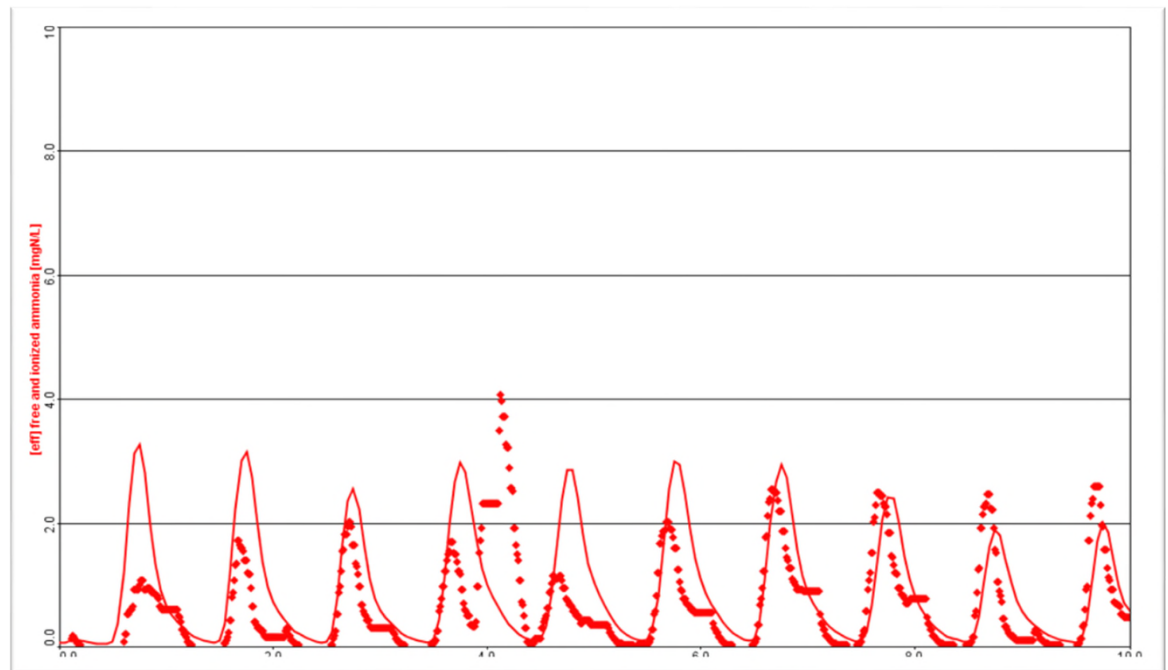
- Concentrations unrepresentative
- Trends incorrect
- Impacts incorrectly inferred



Issues

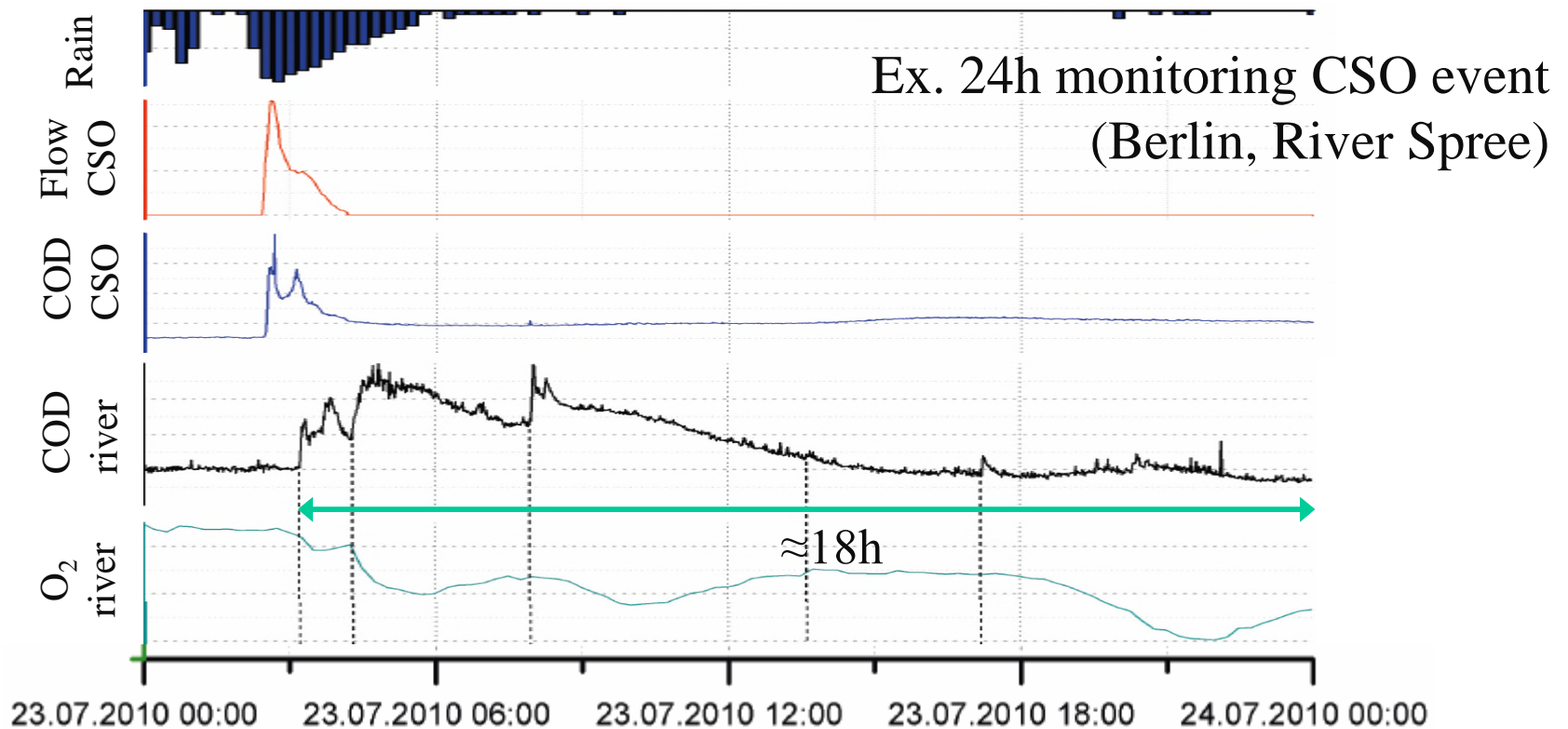
➤ High Frequency Monitoring

- Essentially continuous
- Trends
- Event detection



Problem Definition

➤ Need for advanced data quality evaluation



Problem Definition

➤ Need for advanced data quality evaluation

Effective management of water systems



Monitoring and assessment strategy



Reliable water quality information

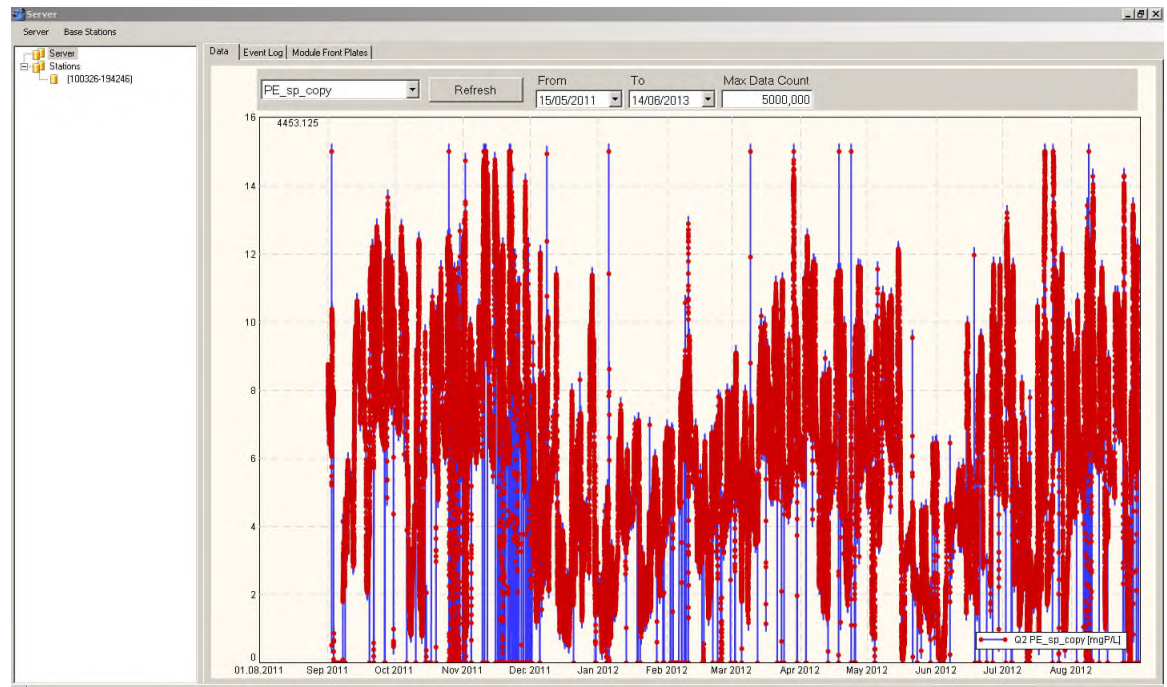


Modelling, forecasting, control...

Issues

➤ Typical Real-Time Data

- Outliers
- Sensor Faults
 - Noise
 - Malfunction
 - Calibration



Issues

➤ Typical Real-Time Data

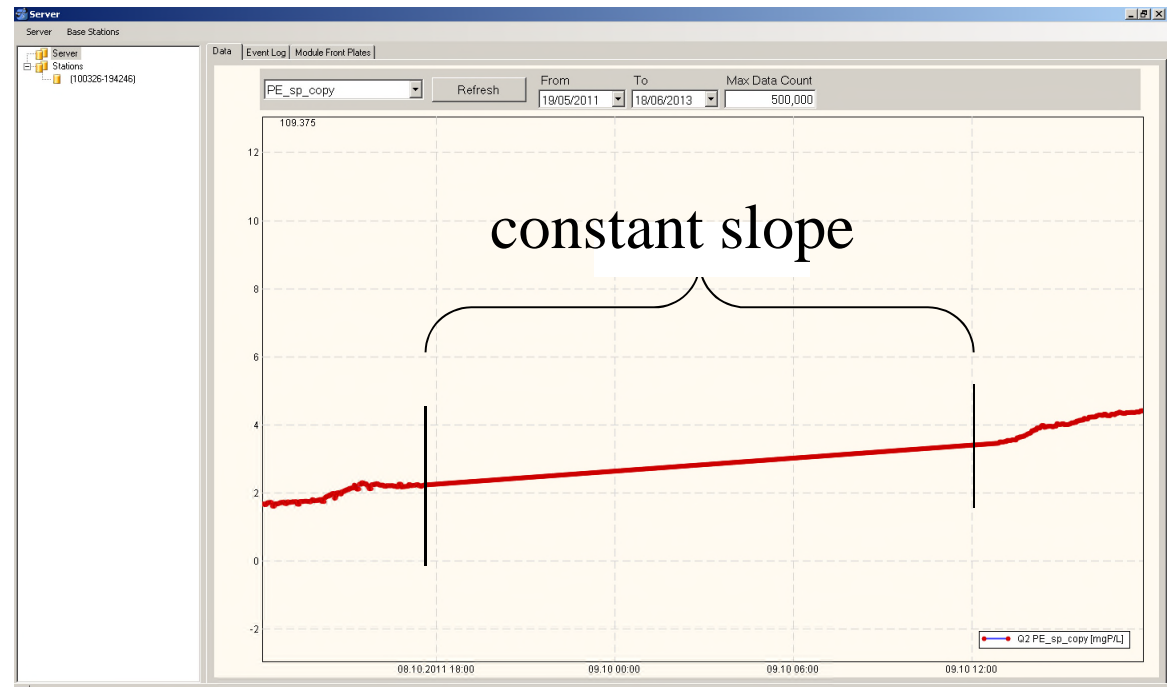
- Malfunction
 - zero



Issues

➤ Typical Real-Time Data

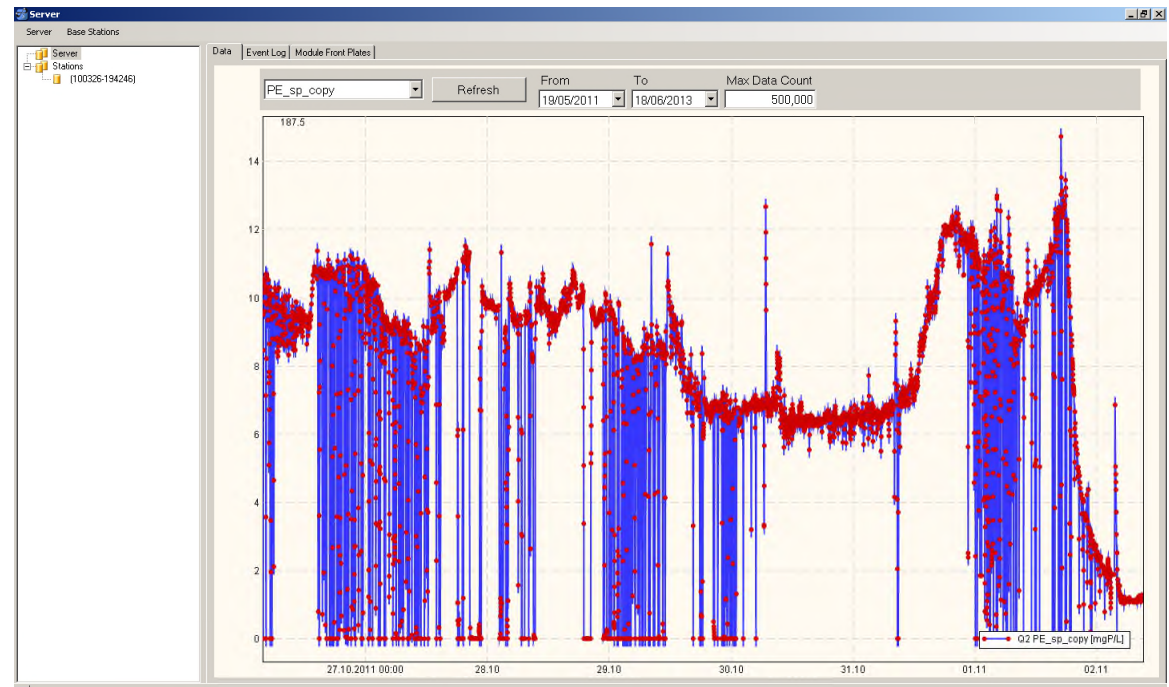
- Malfunction
 - Odd Behaviour



Issues

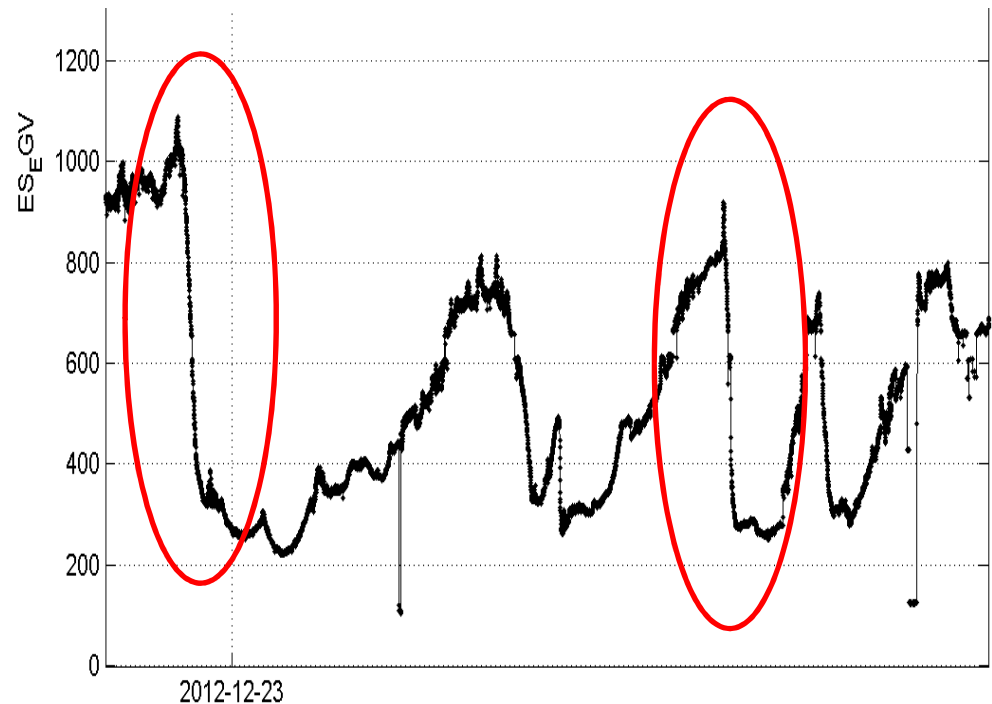
➤ Typical Real-Time Data

- Malfunction
 - Noise



➤ Typical Real-Time Data

- More complicated
 - Detecting the difference between real events and problems



Identified Needs In Water Monitoring

➤ Identified Issues:

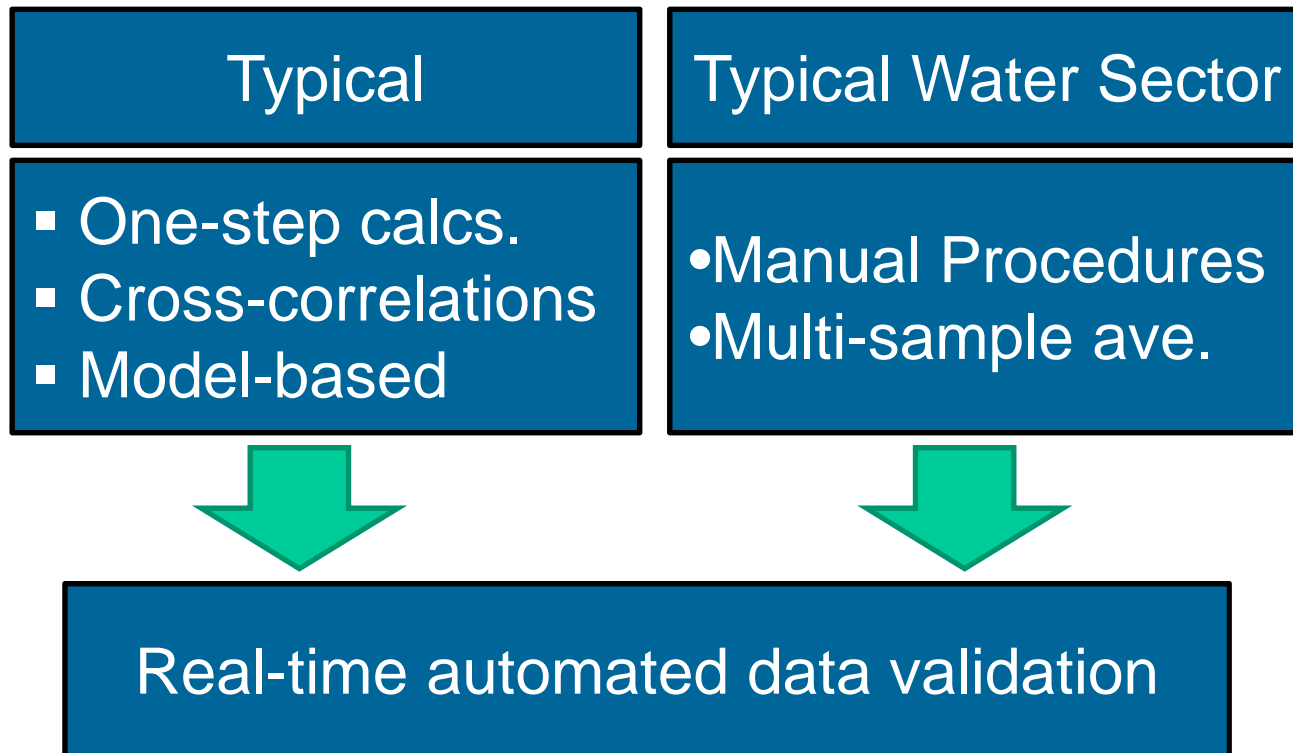
- complex data graveyards too common
- too much post-processing effort
- data from faulty sensors too common

Challenge:
Automated Data Validation



Methods for Data Validation

➤ PrecisionNow Practical Implementation



Classic Methods for Data Validation

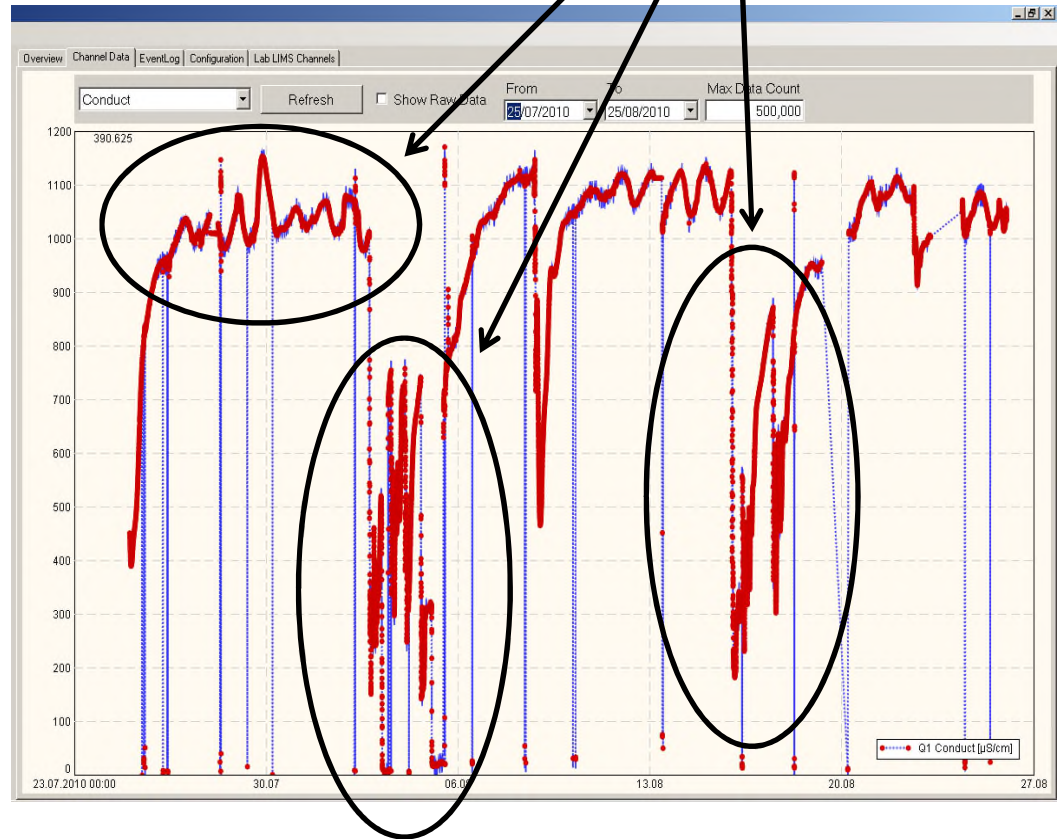
➤ Single data validation: one-step

Method	Description
Manual evaluation	Comparison with grab samples
Constant value (TCV)	Constant value in allowed period
Range	[min, max] allowed values
Rate of change	[min, max] allowed rate of change over time
Running variance	[min, max] allowed StD

Univariate

- Data from Quebec City: St Charles River
 - Conductivity raw data

Noise, Natural Cycle or Event?



Univariate

➤ Data from Quebec City: St Charles River

– Outlier detection
followed by a
LowPass Filter

Noise, Natural Cycle or Event?



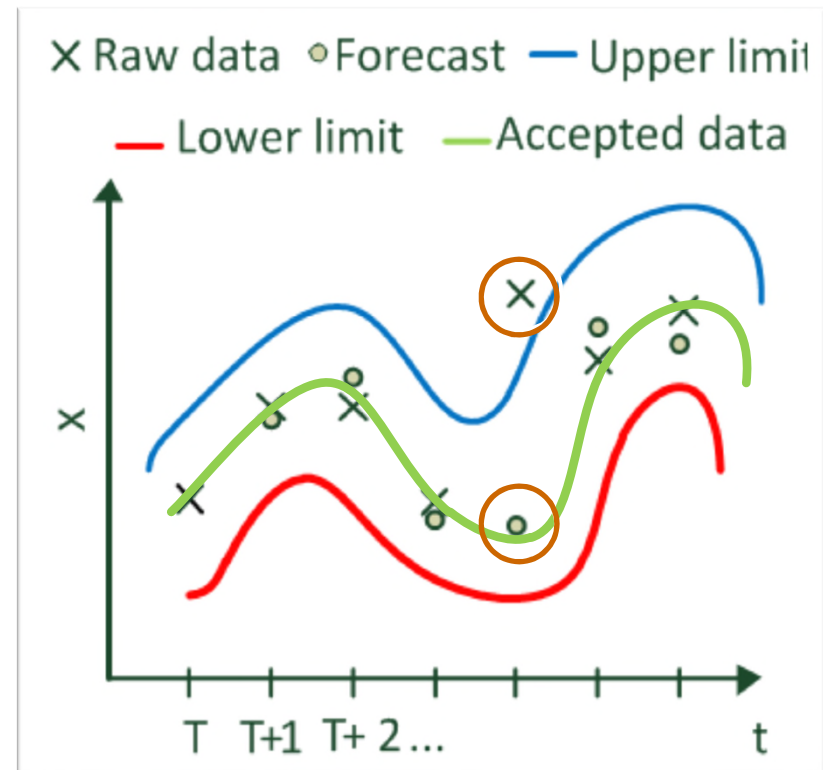
Model-Based Method for Outlier Detection

➤ Univariate time series analysis

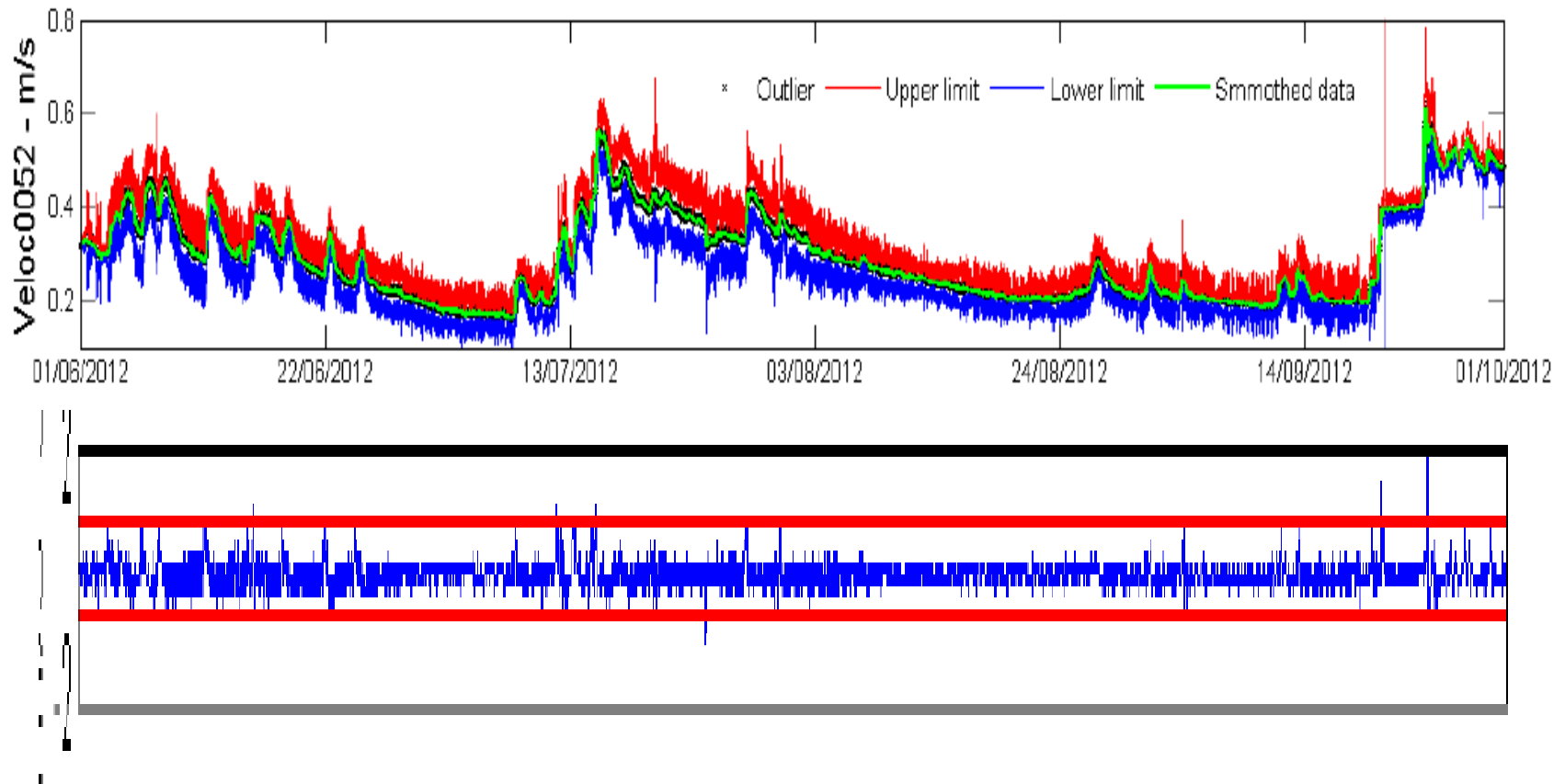
○ Outlier detection

- Model-based forecast of expected data \hat{x}
- Prediction interval

$$x_{\text{lim}} = \hat{x} \pm K \cdot \hat{\sigma}_e$$



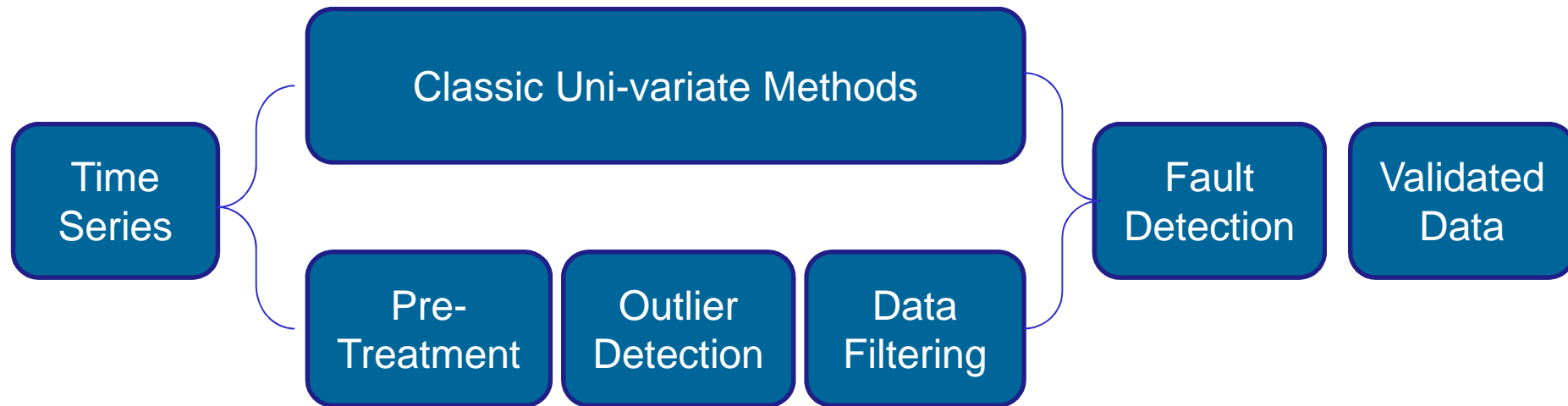
Model-Based Method for Outlier Detection



Combination of Methods

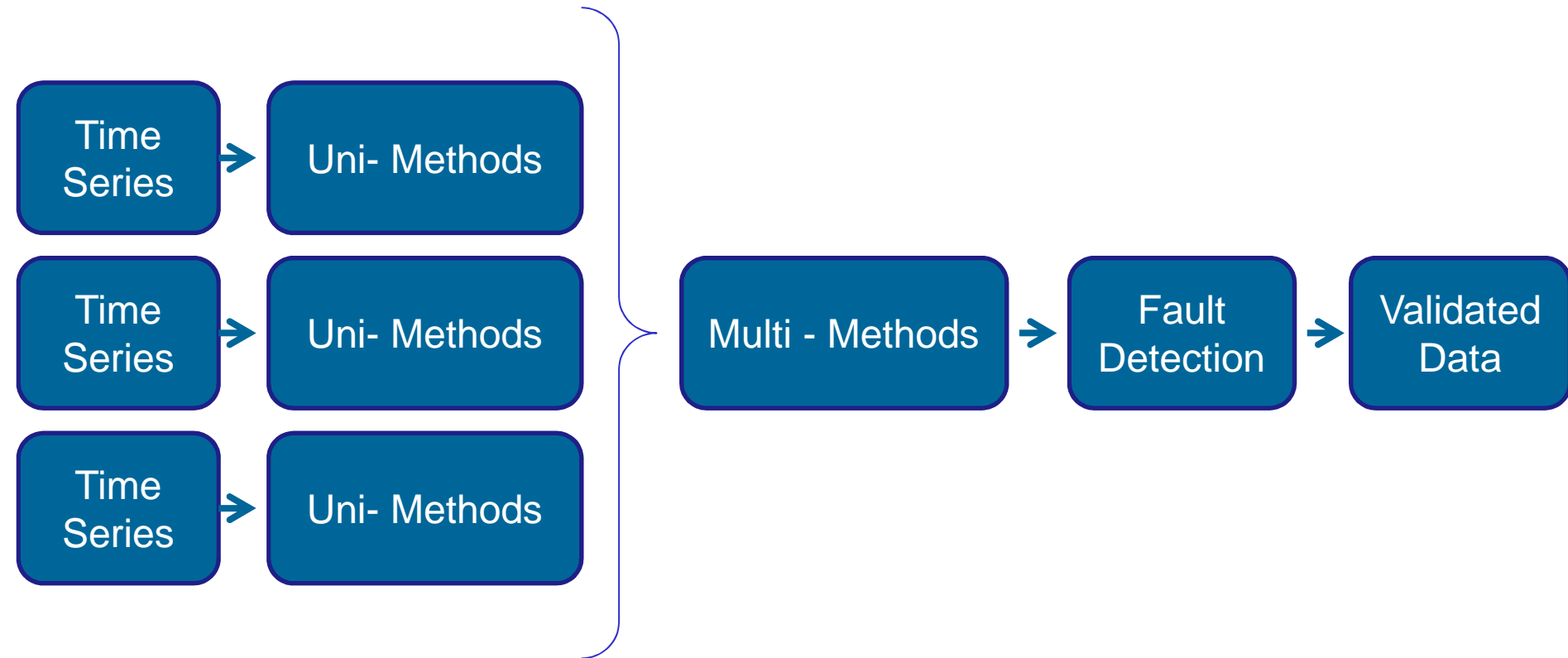
➤ PrecisionNow univariate analysis

- Multi-step method combination



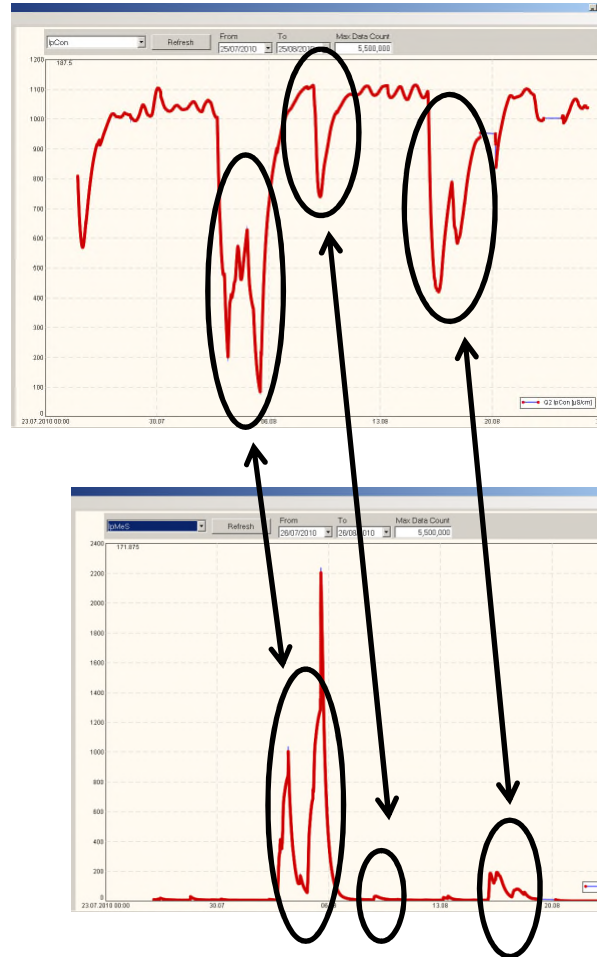
Combination of Methods

➤ Multivariate time series analysis



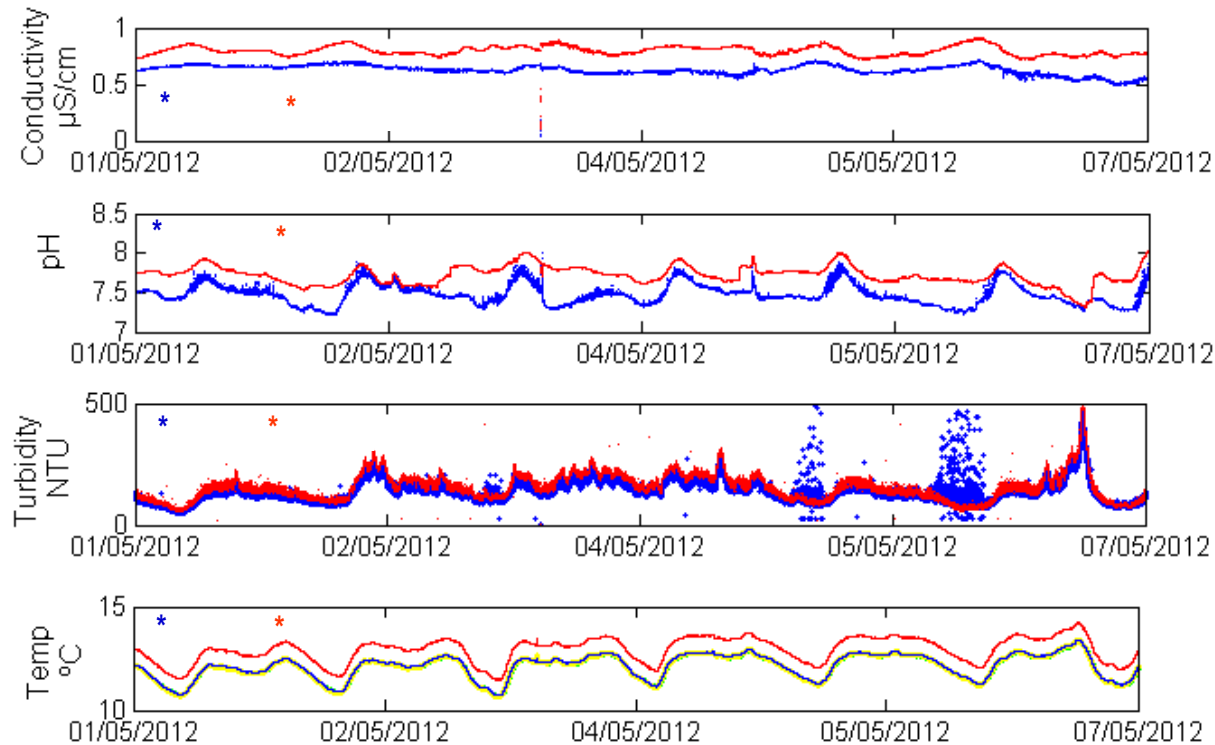
Multivariate – Simple Case

- Data from Quebec City: St Charles River
 - Conductivity vs TSS (data after LowPass Filter)
 - no alarm



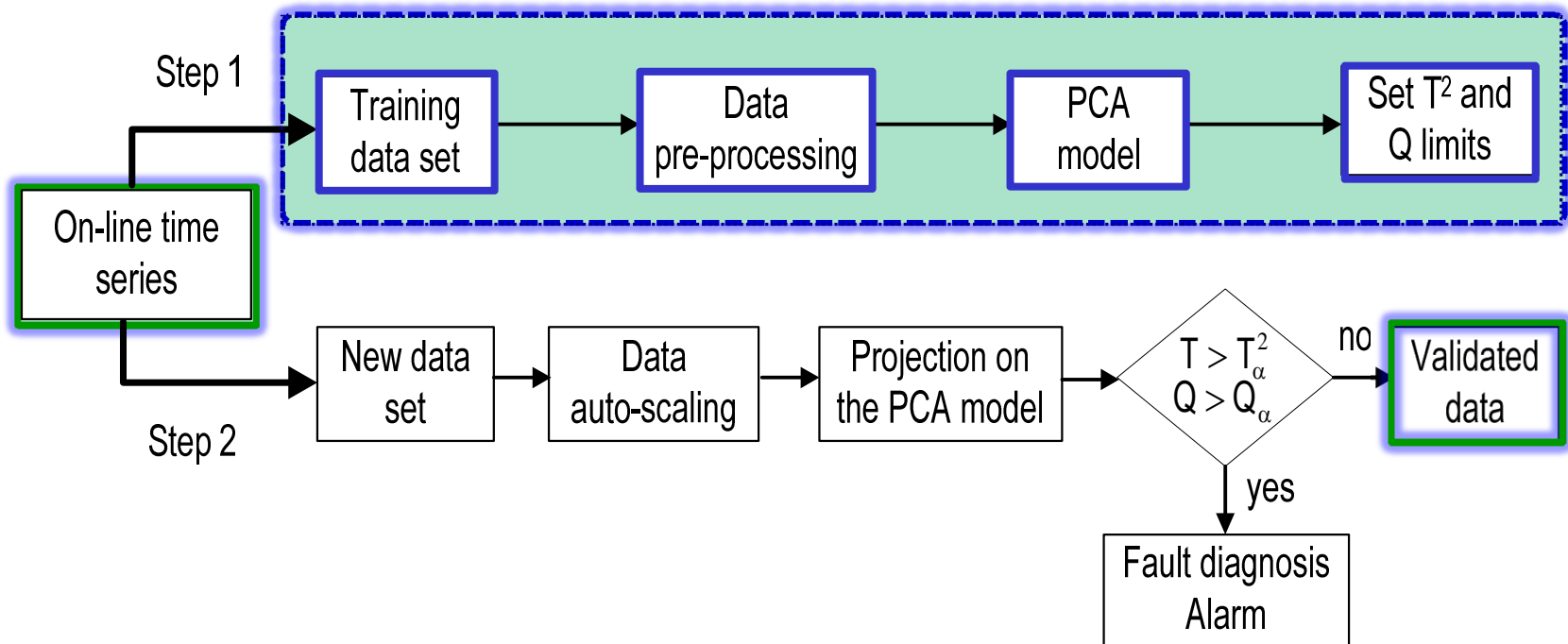
Confirmation of real events as picked up by other measurements

Multivariate – PCA Approach



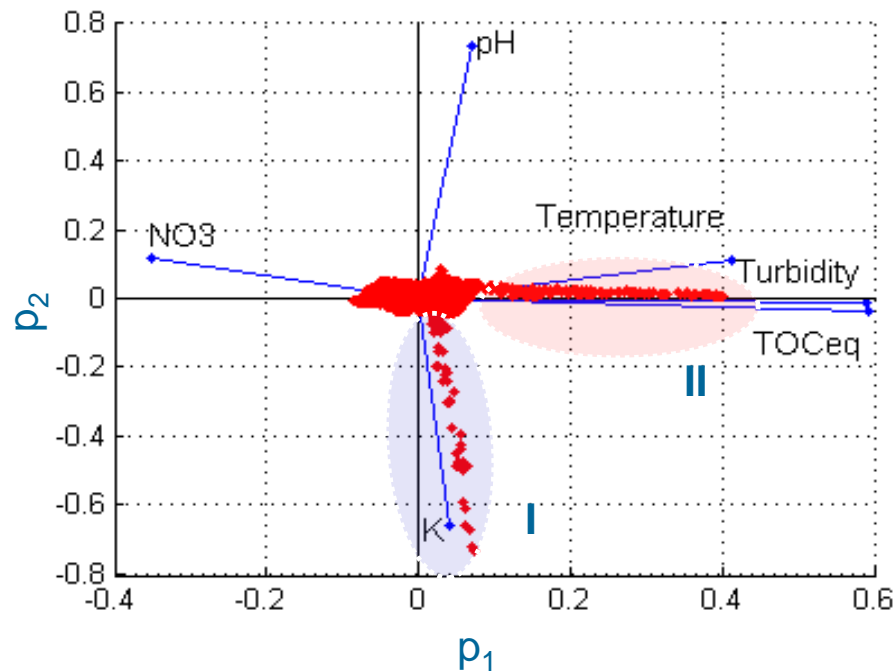
- Variable 20% bias ($\text{Cond}_1, \text{Cond}_2$)
- Variable bias (pH_1, pH_2), ($\text{Turb}_1, \text{Turb}_2$)
- Const. 5% bias ($\text{Temp}_1, \text{Temp}_2$)

Multivariate – PCA Approach

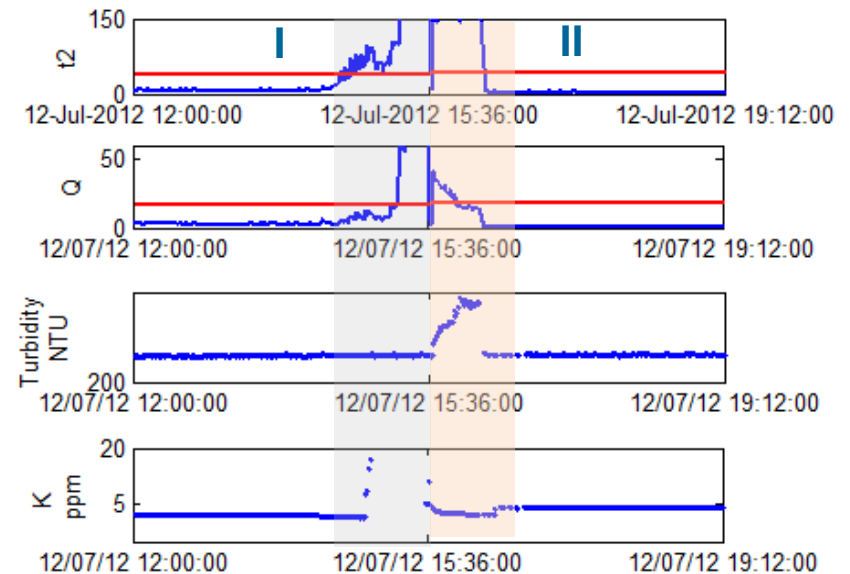


Real-Time Data Modules – PCA

Data in the new space – 2 Components



Statistics period I and II



Conclusions

➤ RSM30 / *PrecisionNow*

- Easily deployed in various environments (WWTP, river,...)
- Data logging
- Customizable, real-time data evaluation capability
- Sensor independent
- Algorithms used as a stand-alone package (office) or in conjunction with an RSM30 (water's edge)

Conclusions

➤ RSM30

- Easily shipped and deployed in various environments (WWTP, river,...)

➤ *PrecisionNow* provides

- Data logging
- Customizable, real-time data evaluation capability
- Sensor independent
- Can be used as a stand-alone package (office) or in conjunction with an RSM30 (water's edge)

Conclusions

- Dealing with faulty sensors represents a challenge for effective WQ monitoring
- Real-time fault detection minimizes post-processing effort, and maximizes response times
- Uni- and Multi-variate methods allow for the detection of multiple faults in real-time

Acknowledgements



*Canada Research Chair
in Water Quality Modeling*

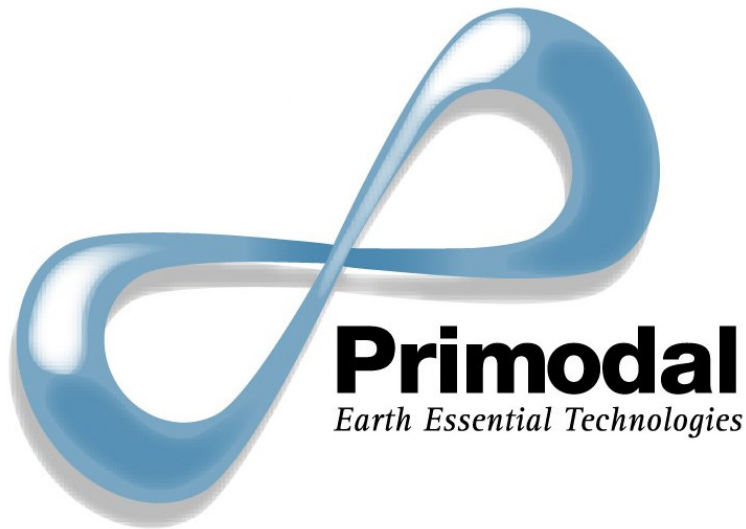


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Fondation canadienne pour l'innovation
Canada Foundation for Innovation

Thank-you !



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